

MONTHLY WEATHER REVIEW.

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No. 3.

INTRODUCTION.

The REVIEW for March, 1894, is based on reports from 3,252 stations occupied by regular and voluntary observers. These reports are classified as follows: 152 reports from Weather Bureau stations; 42 reports from U. S. Army post surgeons; 2,238 monthly reports from State weather service and voluntary observers; 30 reports from Canadian stations; 221 reports through the Southern Pacific Railway Company; 565 marine reports through the co-operation of the Hydrographic Office, Navy Department, and "New York Herald Weather Service;" 5 weekly reports from 1 U. S. Life-Saving station; no reports from navigators on the Great Lakes; monthly reports from local services established in all States and Territories; and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

The WEATHER REVIEW for this month has been prepared under the general editorial supervision of Prof. Cleveland Abbe. The statistical tables are furnished by the Division of Records and Meteorological Data, in charge of Mr. A. J. Henry, acting chief of that division.

CHARACTERISTICS OF THE WEATHER FOR MARCH, 1894.

HIGH AREAS.

The most important areas of high pressure were Nos. XVII and XVIII, which passed from Alberta on the 23d and 27th to the south Atlantic coast on the 28th and 31st, respectively. Coming as they did after several weeks of warm weather they brought disastrous frosts and freezes to the tender vegetation in the Mississippi Valley, Gulf, and south Atlantic States. The mean temperatures for the week preceding their advent and for the week following presented a remarkable contrast, so that many places have during this month experienced both the highest and lowest temperatures on record.

COLD WAVES.

The great cold wave of the 22d-27th, passing over Wyoming, caused a continuous blizzard of seventy hours at Buffalo, in that State, which, so far as known, was never approached in severity by any other storm in that locality.

LOW AREAS.

Several storms that have passed over the Lake region and New England have been quite severe, notably that of the 11th and 12th, but those off the coasts of Washington and Oregon and that of the 23d in the Atlantic Ocean, which passed from New England on the 22d, were among the severest on record.

PRECIPITATION.

A special area of heavy rainfall occurred during the 15th and 21st in Arkansas and Louisiana and a notable snowfall over the Appalachian Range and New England on the 25-30th.

RIVER FLOODS.

Notable floods or high waters were reported from Baker City, Oreg., as also from Arkansas and Louisiana.

AURORAS.

A brilliant and interesting aurora occurred on the 30th, accompanied by a remarkable magnetic storm; both of these phenomena were also observed in Europe on that date.

ATMOSPHERIC PRESSURE.

[In inches and hundredths.]

The distribution of mean atmospheric pressure reduced to sea level for March, 1894, as determined from observations taken daily at 8 a. m. and 8 p. m. (seventy-fifth meridian time), is shown by isobars on Chart II, which also gives the so-called resultant wind direction for this month; these resultants are also given numerically in Tables VIII and IX of the present REVIEW. The pressures here charted are those shown by mercurial barometers uncorrected for the effect of the variation of gravity with latitude; this correction is shown by the numbers printed on the border of Chart II; it should be applied and new isobars drawn by those engaged in special researches.

During March the pressures at sea level have been highest, 30.20, in southeastern Georgia and northern Florida; a minor region of maximum pressure, 30.11, existed off the coast of

northern California. The regions of minimum pressure were 29.90, or less, in British Columbia; 29.93 over Lake Superior and eastward; 29.94 over the Gulf of California and northward to southern Nevada.

The normal distribution of atmospheric pressure and normal resultant wind direction for the month of March were approximately shown on Chart VIII of the REVIEW for March, 1893, as computed by Prof. H. A. Hazen, and are not now reproduced. As compared with the normal for March, the mean pressure for the current month was in excess in the Atlantic and Gulf States, lower Lake region, and Ohio Valley; also slightly in excess in northern California, but deficient throughout the interior of the country. The line of no departure passes from eastern Texas through Arkansas, Indiana, and southern Michigan northeast toward Labrador.

The principal excesses were: 0.10 or 0.12 at middle and southern Atlantic coast stations; 0.13 at Halifax, N. S.; and 0.04 at San Francisco and Eureka, Cal. The principal deficits were: 0.15 at Prince Albert, Saskatchewan; 0.14 at St. Vincent, Minn.

As compared with the preceding month of February, 1894, the mean pressure for March was lower at all stations, except about stationary in the region from Virginia to northern Florida. The principal area of lower pressure was -0.20 to -0.27 in Idaho, Utah, Wyoming, Colorado, Kansas, Nebraska, and the eastern part of South Dakota. The line of fall of 0.10 passes from British Columbia southward, parallel to the coast, into Mexico, and from eastern Texas northeast to the mouth of the Saint Lawrence.

The systematic periodic diurnal variations of pressure are shown by the hourly means given in Table VI.

MOVEMENTS OF CENTERS OF AREAS OF HIGH AND LOW PRESSURE.

The following table shows the date and location of the center at the beginning and ending of each area of high or low pressure that has appeared on the U. S. Weather Maps during the month, together with the average daily and hourly velocities. The monthly averages will differ accordingly as we consider each path as a distinct unit, or give equal weight to each hour of observation; in the first case the monthly average is taken by paths, in the latter case by hours:

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
High areas.										
I.	1, a. m.	0	0	1, a. m.	0	0	Miles.	Days.	Miles.	Miles.
II.	1, a. m.	42	110	1, a. m.	42	110	00	0.0	000	25.0
III.	2, a. m.	28	87	5, a. m.	34	77	1,800	3.0	600	13.1
IV.	2, p. m.	53	115	6, a. m.	52	101	1,100	3.5	314	16.7
V.	4, p. m.	37	114	8, a. m.	33	114	1,400	1.0	400	31.2
VI.	6, a. m.	41	116	8, a. m.	39	94	1,500	2.0	750	38.5
VII.	8, a. m.	39	118	8, p. m.	37	116	150	0.5	000	18.3
VIII.	8, a. m.	41	90	10, a. m.	45	59	1,850	2.0	925	11.1
IX.	9, p. m.	42	125	12, a. m.	38	111	1,100	2.5	440	26.4
X.	13, a. m.	37	125	14, p. m.	39	125	400	1.5	267	19.5
XI.	13, p. m.	50	85	15, a. m.	42	74	950	1.5	633	22.2
XII.	16, a. m.	28	80	16, p. m.	28	80	00	0.5	000	18.3
XIII.	17, a. m.	43	76	18, p. m.	44	59	700	1.5	467	22.2
XIV.	16, p. m.	44	126	18, a. m.	40	113	800	1.5	533	18.3
XV.	18, a. m.	54	103	21, p. m.	47	58	1,100	2.5	440	12.5
XVI.	18, p. m.	45	128	19, a. m.	43	125	200	0.5	000	16.2
XVII.	19, a. m.	54	118	23, a. m.	41	111	1,200	4.0	300	28.2
XVIII.	23, a. m.	55	115	28, a. m.	37	73	1,950	5.0	390	19.5
XIX.	27, a. m.	55	114	31, p. m.	29	78	3,050	4.5	678	000
	30, a. m.	47	127	31, p. m.	42	113	700	1.5	467	000
Sums							18,750	39.0	7,604	21.1
Mean of 15 paths									507	20.0
Mean of 39.0 days									481	
Low areas.										
I.	1, a. m.	30	79	1, a. m.	30	79	00	0.0	000	34.2
II.	1, a. m.	50	89	3, p. m.	46	57	2,050	2.5	820	26.3
III.	1, a. m.	53	115	7, p. m.	53	63	4,100	6.5	631	40.3
IV.	2, p. m.	32	119	2, p. m.	32	119	00	0.0	000	30.3
V.	5, a. m.	47	126	8, a. m.	37	77	2,900	3.0	967	22.2
VI.	6, p. m.	54	113	6, p. m.	54	113	00	0.0	000	35.0
VII.	6, p. m.	43	129	12, a. m.	51	56	4,000	5.5	727	43.8
VIII.	7, p. m.	37	104	9, a. m.	33	96	800	1.5	533	32.8
IX.	12, p. m.	45	92	15, a. m.	48	55	2,100	2.5	840	37.5
X.	12, a. m.	33	78	12, a. m.	33	78	00	0.0	000	57.4
XI.	13, p. m.	31	114	14, p. m.	38	100	1,050	1.0	1,050	0.0
XII.	13, p. m.	55	115	17, a. m.	47	55	3,100	3.5	886	44.4
XIII.	15, a. m.	52	120	20, a. m.	45	55	3,400	5.0	680	0.0
XIV.	18, a. m.	51	124	23, p. m.	47	71	4,050	4.5	900	25.0
XIV a	22, p. m.	44	60	24, a. m.	44	57	1,850	1.5	1,233	16.7
XV.	18, p. m.	30	99	20, p. m.	38	96	900	2.0	450	0.0
XVI.	21, p. m.	46	71	22, a. m.	42	61	550	0.5	000	0.0
XVII.	23, a. m.	30	115	25, a. m.	30	115	00	2.0	000	0.0
XVIII.	23, p. m.	49	95	25, a. m.	53	65	1,600	1.5	1,066	44.4
XIX.	25, p. m.	44	67	26, a. m.	43	56	650	0.5	000	0.0
XX.	27, p. m.	40	100	30, a. m.	47	59	1,500	2.5	600	25.0
XXI.	28, p. m.	53	124	31, p. m.	52	84	1,200	3.0	400	16.7
Sums							35,800	49.0	11,783	31.0
Mean of 16 paths									743	30.4
Mean of 49.0 days									730	

HIGH AREAS.

I.—This appeared on the morning of the 1st, central in Wyoming, and was the continuation of low area No. VII of the month of February. It had no further motion, and must be considered as having merged into high area No. III. In connection with this area warning of a marked fall in temperature was sent on the 2d, 10 a. m., to Helena and Fort Custer, Mont., and Williston and Bismarck, N. Dak.

II.—Was central on the morning of the 2d in the eastern portion of the Gulf of Mexico; it moved northward into Ohio and thence slowly southeast and disappeared on the 5th off the coast of North Carolina.

III.—This area was nearly central in Alberta on the morning of the 3d, and had apparently moved southeastward on the eastern slope of the Rocky Mountains from Athabasca, while low area No. III was far to the south and moving eastward. By the 6th, a. m., the highest pressure had moved southeast into Manitoba, after which it can not be traced on our maps. In advance of this area cold wave signals were ordered as follows: 2d, p. m., North Dakota, South Dakota, Nebraska, Kansas, Minnesota, and Iowa. 3d, a. m., Wyoming and South Dakota; 3d, p. m., Wyoming, Colorado, Nebraska, Minnesota, Iowa, and Wisconsin. 4th, a. m., Kansas, Iowa, and Wisconsin; 4th, p. m., Nebraska, Texas, Minnesota, Iowa, and Wisconsin. 5th, a. m., Kansas, Oklahoma, Indian Territory, Texas, Iowa, Missouri, Arkansas, Illinois, Michigan, and Wisconsin. 6th, a. m., Michigan, Indiana, Ohio, Kentucky, Pennsylvania, and West Virginia. 7th, a. m., Vermont.

IV.—This area appeared on the 4th, p. m., in southern Nevada and disappeared on the 5th, p. m., in New Mexico. Although it appeared at first to be pushing northeastward over southern California, yet it is allowable to consider it as a southern branch from high area No. III, and, therefore, consisting of cold air flowing southward to the Gulf of California.

V.—This area appeared on the 6th, a. m., in northern Nevada, where it also disappeared the same day.

VI.—This appeared on the 8th, a. m., in Nevada and disappeared on the same day.

VII.—This appeared on the 8th, a. m., in Illinois, and subsequently, by joining a larger area in Canada, appeared to have moved northeastward. The combined area disappeared on the 10th, a. m., off Cape Breton.

VIII.—Appeared first on the 9th, p. m., off the coast of northern California; moved slowly southeastward, and on the 12th diffused northward and southward over the Rocky Mountain region and disappeared. Cold wave signals were ordered on the 10th, a. m., for Colorado, Nebraska, Kansas, and Iowa; 10th, p. m., Wisconsin.

IX.—This appeared off the coast of northern California on the 13th, a. m., pushed slowly northeastward during the 13th and 14th, then retired southwest and disappeared.

X.—Appeared on the 13th, p. m., north of Lake Superior, moved southeast and disappeared on the 15th, a. m., on the middle Atlantic coast. Cold wave signals were ordered on the 14th, a. m., for Vermont.

XI.—Pressure rose steadily over southern Florida from the 12th, p. m., to the 16th, a. m., and on the latter date high area No. XI may be considered as central in this region and as tributary to low area No. XIII, which was then central in Assiniboia, while high area No. XIII was approaching the coast of Oregon. During the 16th pressure began to fall in Florida, but to rise in the Middle States and New England, but this new high area, No. XII, must be considered as independent of No. XI.

XII.—This was central on the 17th, a. m., in central New York and 17th, p. m., south of Long Island, after which it moved northeast and disappeared on the 18th, p. m., off Nova Scotia.

XIII.—Appeared on the 16th, p. m., west of Oregon; pushed northeast and then southeast until, on the 18th, a. m., it was central in northern Utah, while a similar high area was central north of Manitoba; these two formed part of a belt of high pressure on the south and east sides of low area No. XIV, which was then central in British Columbia.

XIV.—Slight rise of pressure occurred in Saskatchewan on the 17th, and on the 18th, a. m., the highest pressure was central in the northwestern part of Manitoba; it moved southeastward, keeping north of the Great Lakes, and disappeared on the 21st, p. m., south of Newfoundland.

XV and XVI.—The map of the 19th, a. m., shows a sudden rise of pressure, or high area No. XV, on the coast of California, Oregon, Washington, as also in Alberta and probably Athabasca, while high area No. XIV was already moving southeastward over Manitoba. This general rise of pressure followed the southeast movement of low area No. XIV, over Montana. It seems plausible that high area No. XV was west of Oregon on the 18th, p. m., and pushing northeastward, although the trend of our Pacific coast intersected its isobars in such a way as to make an apparent increase of pressure progress southward along the coast. Cold wave signals were ordered 20th, a. m., for South Dakota; 20th, p. m., Nebraska, Kansas, and Iowa. 21st, a. m., South Dakota, Kansas, Oklahoma, Indian Territory, Minnesota, Iowa, Missouri, and Wisconsin. Another inflow of cold air from the northward may have contributed to the formation of the other area of high pressure, No. XVI, which appeared on the 19th, a. m., in northwestern Alberta. High area No. XV behaved as a mass of air banked up on the western side of the Rocky Mountain and Sierra ranges, while high area No. XVI moved south and obliterated high area No. XV. This was the most extensive and well-defined area of high pressure during March. By the 23d, a. m., the central highest had moved southeast over Assiniboia, and thence southwest into Utah, while the outflow of cold air had at that time extended as a norther over Texas and the Gulf of Mexico, and also as a cold, dry easterly wind, with frost, over California, Oregon, and Washington. The blizzard in Wyoming attending this high area lasted 70 hours and was more severe than any of previous record. As usual, this advance of such an extensive high area was also attended by the development of low pressure in Mexico, and its gradual extension northward into southern California and Texas; undoubtedly, the area of low pressure characteristic of the Gulf of California, and which we have before described as a branch of the equatorial trough, was now rapidly advancing northward off the Pacific coast of Mexico, and by the 23d, a. m., the northern end of this area of low pressure had reached Yuma, Ariz., and retained its position during the rest of the month. After the 23d and as the temperature rose over the Rocky Mountain plateau region pressure fell at the high stations, but a second high area immediately followed in Alberta.

XVII.—After a slight fall on the 22d pressure again rose in British Columbia and Alberta on the 23d, a. m. This center moved slowly eastward, but its northerly winds and rising pressure extended rapidly southward to the Gulf of Mexico, and the area of high pressure became a ridge whose southern end covered Mexico while its northern end reached far northward into British America, apparently beyond N. 60°. If the isobar of 30.6 marked the position of the crest of an extensive wave in the upper atmosphere moving slowly eastward, or if it was simply a branch protruding from the great area of high pressure in Asia, or if it was simply the locus of the intersection, at the earth's surface, of a broad sheet of descending air, or if, finally, we view it as the locus of a standing wave or nearly stationary system of anticyclonic circulation, still, in either case, it must have had an intimate dependence upon the obstruction offered by the Rocky Moun-

tain range. By the 27th, a. m., this area had divided into a northern and southern portion, respectively, central in Alabama and the upper Lake region; the latter disappeared on that date, but the former continued eastward, as usual, and disappeared on the 28th off the middle Atlantic coast.

In connection with this high area special warnings of frosts and low temperature for Alabama, Mississippi, Louisiana, Texas, eastern New York, eastern Pennsylvania, Maryland, Virginia, and West Virginia were sent out at 10 a. m. of the 25th.

Cold wave signals were ordered as follows: 24th, a. m., Iowa, Missouri, Illinois, and Michigan; 24th, p. m., Arkansas, Illinois, Ohio, Kentucky, Tennessee, New York, western Pennsylvania, eastern Pennsylvania, Maryland, District of Columbia, Virginia, and Georgia. 25th, a. m., Louisiana, Mississippi, Alabama, New York, Vermont, North Carolina, South Carolina, and Georgia. 24th, 11 p. m., northeast wind signals were ordered for Corpus Christi and Galveston, Tex., and information signals at Port Eads and New Orleans, La. 25th, 10 a. m., northwest signals at Milwaukee, Wis., and Grand Haven, Mich., also for Port Eads and New Orleans, La., Mobile, Ala., and Pensacola, Fla., and information signals at Cedar Keys, Fla. 26th, 10 a. m., northwest signals were ordered for the entire coast from Cedar Keys, Fla., to Eastport, Me.

XVIII.—On the 26th, p. m., pressure was falling in Alberta and British Columbia, but this was followed immediately by a rise, especially on the east side of the Rocky Mountains, and on the 27th, a. m., pressure had risen to 30.62, or 0.36 in twelve hours, at Edmonton, Alberta, with light winds and clear weather, while at Seattle, Wash., it had risen only 0.02. The area of high pressure thus announced moved rapidly southeast along the eastern slope, while low area No. XX developed to the southward. It was central in Texas on the 29th, a. m., after which the highest pressure moved eastward and disappeared on the 31st east of Florida. Cold wave signals were ordered, 27th, p. m., in Colorado, Nebraska, Kansas, Oklahoma, Indian Territory, Texas, and Missouri, and 28th, a. m., Texas, Minnesota, Iowa, Missouri, Arkansas, Wisconsin, Illinois, and Tennessee.

XIX.—This appeared to have been west of Oregon on the 30th, a. m., and to have extended eastward into Idaho in connection with low area No. XXI, which was then in Assiniboia. It reached the southeastern corner of Idaho on the 31st, a. m., and its subsequent history belongs to the month of April.

LOW AREAS.

I.—This area appeared on the 1st, a. m., east of Florida, but its further history belongs to the Atlantic Ocean.

II.—1st, a. m., was north of Lake Superior, moved rapidly eastward, and on the 2d, p. m., was at the mouth of the St. Lawrence; it appeared then to have turned rapidly southeast, as a low was central on the 3d, a. m., near Halifax, N. S., but this may have been a junction with low area No. I. 3d, p. m., was central south of Newfoundland, after which it disappeared from our maps.

III.—Central the 1st, a. m., in the northern part of Alberta, having apparently come southeast through British Columbia, moved slowly southeast, and on the 2d, p. m., was central in Manitoba, while a trough of low pressure reached southwest into Idaho, and high area No. III followed rapidly behind. This trough then moved southwestward, and on the 3d, p. m., was central in southwest Wyoming. On the 4th, p. m., the lowest pressure extended as a narrow trough from Kansas through central Minnesota and the western portion of Lake Superior into Lake Ontario, while the extensive high areas, Nos. III and II, were central in Saskatchewan and off Cape Hatteras, N. C., respectively. By the 5th, a. m., the southern end of this trough had partly filled up, and the lowest pressure was

central in Minnesota; as this center passed slowly eastward high southwest winds and rain prevailed in the lower Lake region. The low pressure disappeared on the 7th, p. m., over the Gulf of St. Lawrence. In connection with this area wind signals were ordered on the 4th, 11 p. m., at Grand Haven, Mich., and along the Gulf coast from Corpus Christi, Tex., to Port Eads, La., and information signals from Mobile, Ala., to Key West, Fla. On the 6th, when the storm center was over Lake Huron, signals were ordered for southwest winds from Norfolk, Va., to Boston, Mass., and at 11 p. m. information signals at Portland and Eastport, Me. 4th, 10 p. m., while the trough of low pressure was central in Kansas, the following special warning was sent: "Severe local storms for Illinois and Missouri." On the 6th, 11 a. m., when the low trough was in Michigan, the following special warning was sent: "Marked fall in temperature to about freezing in Tennessee and Kentucky."

IV.—On the 2d, p. m., pressure had fallen in Arizona and southern California, and the low area peculiar to that region spread northward until, on the 3d, a. m., it had joined low area No. III, forming a trough of low pressure. On the 4th, a. m., pressure had risen in California and Arizona, and the trough became an area of low pressure, which has been described as low area No. III.

V.—On the 5th, a. m., pressure had fallen on the coast of Washington and Oregon, and by the 5th, p. m., a well-defined low area was central in Washington. This spread rapidly southeast and had disappeared entirely in that region by the 6th, a. m., but a trough of low pressure seems to have resulted on the eastern slope of the Rocky Mountains, so that on the morning of the 6th, a. m., a slight depression was central between Wyoming and North Dakota, while another and deeper depression existed simultaneously in Alberta and Athabasca. On the 6th, p. m., the southernmost of these depressions, which is called No. V, had moved southeast into Oklahoma and the northernmost, which is called No. VI, was in northern Alberta. The latter soon disappeared in the presence of a larger depression to the westward, while the southern area continued to develop. On the 7th, a. m., the latter was central in Missouri; 7th, p. m., in Kentucky; 8th, a. m., in Virginia, where it disappeared.

VI.—Appeared on the 6th, p. m., in northern Alberta. The limited area covered by our weather maps prevents us from ascertaining whether this is to be regarded as the northwestern portion of a trough transferred across the Rocky Mountains from low area No. V, or whether it was a forerunner of low area No. VII; if the latter be true its appearance would be entirely analogous to numerous cases in more southern latitudes, where a low approaching the Rocky Mountains expands into a larger area over the plateau, out of which there forms a depression on the eastern slope far to the southeast of the original low.

VII.—On the 6th, p. m., pressure began to fall on the coast of Oregon, Washington, and northern California, and on the 7th, a. m., a low area was central in British Columbia, having evidently moved east or northeastward from the Pacific. By the 7th, p. m., this center was on the Rocky Mountain Divide, between British Columbia and Alberta, and by the 8th, p. m., had passed entirely over, and the lowest pressure, 29.00, was at Edmonton, Alberta; meanwhile, the area of falling barometer had extended rapidly to the southeast and a minor depression was central in Texas. An area of low barometer had at no time passed over the southern portion of the Rocky Mountain plateau in such a way as to indicate that the low pressure on the eastern slope of the Rocky Mountains had passed across the whole length of that range as a long trough of low pressure, but, on the contrary, the low pressure on the eastern side from Texas to Montana must be attributable, in some way, to the movement of the winds

toward the low pressure in Athabasca and Saskatchewan. By the 9th, p. m., the area of lowest pressure, or isobar of 29.45, extended as a long oval from Alberta eastward through Montana, while the larger depression, of which this was the center, extended from Mexico northward beyond our stations; out of this large region a special area of low pressure and cyclonic whirl was developed which was central in eastern Nebraska on the 10th, a. m., and therefore, as usual, far south of the center of the larger depression. This developed into a violent storm moving northeastward over Wisconsin and Lake Superior, thence eastward into Labrador, where it disappeared on the 12th.

In connection with this storm center, wind signals for southwest winds were ordered on the 10th, 2 p. m., at Milwaukee, Wis., and Grand Haven, Mich., and changed at 10.30 p. m. to northwest signals. On the 11th, at 10.30 a. m., southeast winds were signaled from Sandy Hook, N. J., to Eastport, Me., but at 10.30 p. m., were changed to southwest signals.

VIII.—This slight depression appeared on the map on the 7th, p. m., in Colorado, at the southern extremity of the depression produced by low area No. VII. During the 8th pressure continued to fall in the southwest, and on the 8th, p. m., this depression was in central Texas, while brisk, cool northwest winds prevailed on the south and east Rocky Mountain slope from high area No. VI, which was then central in Nevada. By the 9th, a. m., this depression had filled up and disappeared on the southern border of Oklahoma.

IX.—During the 11th the barometer continued low throughout the region from Washington to Manitoba and northward, while low area No. VII was moving eastward toward Labrador; minor areas of low pressure appeared on the 11th and 12th in Alberta and Saskatchewan and in Wisconsin, forming a belt of low pressure which had disappeared by the 12th, p. m., leaving a definite area, No. IX, central in Wisconsin. This moved eastward over lakes Michigan, Huron, and Ontario, developing rapidly as a severe storm center. It was central on the 13th, p. m., near Oswego, N. Y., and on the 14th, a. m., near Northfield, Vt., and on the 14th, p. m., was near the coast of Nova Scotia, and disappeared on the 15th, a. m., in Newfoundland. On the 13th information signals were displayed from Sandy Hook, N. J., to Eastport, Me.

X.—On the 12th, a. m., a depression appeared on the south Atlantic coast; it gave every appearance of being the western edge of a revolving storm central far to the eastward, and its further history belongs to ocean meteorology. On the 12th, 10 p. m., information signals were displayed from Savannah, Ga., to Wilmington, N. C.

XI and XII.—On the 13th, a. m., pressure had fallen slightly in California southeastward over Mexico, Texas, and Arkansas, and by the 13th, p. m., it was evident that a general depression was advancing northeastward from the Pacific over northern Mexico, while at the same time another, No. XII, was advancing rapidly southeastward from British Columbia, Athabasca, and Colorado. Nothing can more vividly illustrate the unstable condition and the turbulent movement of the atmosphere during its transition from winter to summer than these great changes of pressure over such large areas. This extended depression maintained its existence during the 13th, but was rapidly modified during the 14th. The definite area of low pressure, No. XI, was located in central Texas on the 13th, p. m., and in Oklahoma on the 14th, p. m., as the southern end of a trough trending north and south and having low area No. XII near its center in the eastern part of North Dakota. During the 14th and 15th low area No. XI moved eastward, diminishing in importance, and finally disappearing on the middle Atlantic coast. No. XII having stretched southward on the 14th rapidly recovered on the 15th; it was central on the 15th, a. m., near Lake

Superior, after which it passed eastward, with high southerly winds in the Lake region, and disappeared on the 17th, a. m., over Newfoundland.

In connection with these areas, southeast winds were signaled at Corpus Christi, Tex., on the 13th, 11 p. m.; also at Portland and Eastport, Me., 14th, 10 a. m., and Milwaukee, Wis., 10 p. m.; northwest winds at Delaware Breakwater and Atlantic City, N. J., 14th, 11 a. m.; and from Sandy Hook, N. J., to Boston, Mass., 14th, 10 a. m. On the 15th, 10 a. m., southwest winds at Grand Haven, Mich., and at 10 p. m., information signals from Sandy Hook, N. J., to Boston, Mass.

XIII.—On the 14th, p. m., pressure began to fall in British Columbia, and on the 15th, a. m., low area No. XIII was central in that region, having apparently moved southeastward along the Rocky Mountain range; it continued in that direction until the 17th, a. m., when it was central in South Dakota, and represented a very large depression trending northeastward to Hudson Bay and southwest beyond Mexico, while an equally extensive area of high pressure, No. XIII, was advancing eastward upon the Pacific coast. On the 18th the center passed northeast over Lake Michigan attended by high winds. On the 19th, p. m., the storm was central in the Gulf of St. Lawrence, and on the 20th it passed south of Newfoundland, and its subsequent history belongs to the Atlantic Ocean.

In connection with this storm center, northwest winds were signaled on the 19th, 10 p. m., from Narragansett, R. I., to Eastport, Me.

XIV and XV.—After a slight rise the pressure again fell in British Columbia, and on the 18th, a. m., low area No. XIV was apparently central in that province. This moved rather rapidly southeastward, and on the 19th, a. m., was central in southeastern Montana, while at the same time pressure had fallen southwestward over the central Rocky Mountain plateau, and a depression, No. XV, had also passed from the Gulf of California to Texas. The former, No. XIV, moved slowly southward into Colorado and western Kansas where it remained nearly stationary, while the latter moved slowly northward, and both united on the 21st, a. m., in the latter State.

On the 18th, while high area No. XIII extended as a ridge from Manitoba south and west into California, the northerly winds of New Mexico and western Texas seem to have conspired with the southeast winds of the eastern portion of Texas in developing a low area, No. XV, in the region between them, and this was central near San Antonio, Tex., on the 18th, p. m.; it had partly filled up by the 19th, a. m., but again developed rapidly during that day, moving slowly into eastern Texas, where high southeast winds prevailed on the 19th, p. m. At this date we have, therefore, two independent storm centers in Colorado and Texas, respectively, the former attended by lighter winds, but the latter attended on the northern side by heavier winds and on its eastern side by rain. As before stated, low area No. XV moved slowly northward into Kansas, while No. XIV moved southward into the same State, and on the 20th, p. m., these had united into an important storm center in that region. On the 21st, a. m., high northerly winds, with snow, prevailed over Colorado, Nebraska, North and South Dakota, Minnesota, and Lake Superior, while warm southerly winds, with rain, prevailed eastward to the middle Atlantic States; a belt of strong thermal and barometric gradients extended from New Mexico to Manitoba.

On the 21st, p. m., the combined storms were central in northwestern Iowa, with high winds on all sides, except in a small region to the southeast. On the 22d, a. m., the principal depression was central in southern Minnesota and a minor depression, with cyclonic whirl, had apparently formed in extreme northern Indiana, but this latter soon disappeared

and the main storm center moved eastward across lakes Michigan and Huron and was central near the latter on the 23d, a. m., while high westerly winds prevailed over the Lakes and a southeast storm prevailed on the middle and east Atlantic coasts. During the night of the 22–23d the central depression divided into two portions, of which the principal one, No. XIVa, passed over the middle Atlantic States and northeastward along the coast, while the original but now the minor area, No. XIV, passed from Lake Huron into Labrador and disappeared. The new storm center, No. XIV, passed south of Newfoundland on the 24th, a. m., and its further history belongs to the Atlantic Ocean.

In connection with these centers southeast winds were signaled on the 19th, 10 p. m., from Port Eads, La., to Pensacola, Fla., and information signals at Cedar Keys and Key West, Fla., and Corpus Christi, Tex. 20th, 2 p. m., southeast winds at Grand Haven. 21st, 11 p. m., information signals at Grand Haven, Mich. 23d, 11 a. m., southeast wind signals from Norfolk, Va., to Eastport, Me. 23d, 11 a. m., the following special warning was sent to the secretaries of the Maritime Exchanges at New York and Philadelphia: "Severe storm on the Atlantic coast."

XVI.—On the 21st, p. m., a small whirl and depression seem to have developed in the St. Lawrence Valley at the extreme northeast end of the trough containing low areas Nos. XIV and XV. This whirl developed in extent, and on the 22d, a. m., was apparently central south of Nova Scotia, where it disappeared from our maps.

XVII.—On the 22d, p. m., while high area No. XVI was advancing over the Rocky Mountain plateau region, a decided depression was manifest south of Arizona, which was evidently a reappearance of the low area peculiar to the Gulf of California and the adjacent Pacific Ocean; although it soon filled up, this area reappeared twice during the remainder of the month and, as usual, always in connection with the movement of high areas on the Rocky Mountain plateau, as though the northward advance of low areas from the equatorial belt of the Pacific, toward Arizona, was immediately followed by a corresponding advance of high areas southward toward the same region.

XVIII and XIX.—On the 23d, p. m., while high area No. XVII was central in Saskatchewan, the high, cold, northerly wind on its eastern border seems to have developed the low area No. XVIII which was then central in southern Manitoba. We have no observations to show the earlier history of this depression and, indeed, it is quite likely to have rapidly developed on that date in northern Manitoba, so that its course was first toward the south-southeast until midnight of the 23d, after which it turned eastward and by the morning of the 24th was central at the eastern end of Lake Superior. High westerly winds and snow prevailed that day over the Lake region. During the 25th the center moved down the St. Lawrence Valley and disappeared at 8 p. m. in Labrador, while a new depression, No. XIX, developed off the New England coast as soon as the cold northwesterly winds reached that region, and passed northeastward on the 26th south of Newfoundland, developing on the 27th into a severe storm whose history belongs to the Atlantic Ocean. On the 24th, 10 a. m., information signals were displayed from Sandy Hook, N. J., to Eastport, Me., and northwest wind signals at Grand Haven, Mich.

XX.—During the 27th the cold northerly winds on the north side of high area No. XVIII, then central in Assiniboia, and the southerly winds from high area No. XVII, central in the Gulf States, met on the east Rocky Mountain slope, and out of the moderate depression that had previously existed, developed a well-marked area of low pressure with cyclonic winds that, on the 27th, p. m., was central in western Kansas; this moved eastward, accompanied by high winds, low tem-

peratures, and snow, but the central barometric readings, which were at no time low, except by comparison with the surrounding highs, suddenly rose, and on the 29th, a. m., had become a trough with a pressure of about 30.05 in western New York and Pennsylvania. On the 29th, p. m., however, as this trough passed to the Atlantic Ocean, it developed into a storm center that moved northeastward, and, on the 30th, a. m., was central between Newfoundland and Cape Breton.

Information signals were ordered on the 27th, 10 p. m., at Corpus Christi and Galveston, Tex., and northwest signals on the 28th, 1.30 p. m., at the same places; on the same date, at 10 p. m., northwest signals were ordered from Port Eads, La.,

to Pensacola, Fla., and on the 28th, 10.40 a. m., southeast wind signals at Grand Haven, Mich.

XXI.—On the 28th, p. m., low pressures developed on the Pacific coast, both in the Gulf of California and in British Columbia. The latter moved eastward, reaching Manitoba on the 30th, a. m., and Minnesota on the 30th, p. m., after which it turned northeast and passed through Canada north of our stations, but accompanied by high southwest winds over the Lake region on the 31st.

On the 30th, p. m., information signals were ordered for Grand Haven, Mich., and on the 31st, 10.30 a. m., northwest signals for the same place.

NORTH ATLANTIC METEOROLOGY.

[Pressure in inches and millimeters; wind-force by Beaufort scale.]

The normal barometric pressure for March over the North Atlantic Ocean, as deduced from international simultaneous observations, is highest, 30.10 to 30.16 (764 to 766), in a belt extending from the west coast of Africa into Florida, between parallels N. 20° to N. 30°; a corresponding belt prevails on the Pacific Ocean west of the peninsula of lower Florida. The region of lowest pressure, 29.65 to 29.70 (752 to 754), includes Iceland and the southern end of Greenland; a still lower area of low pressure apparently exists between North Cape and Nova Zembla; in the Pacific Ocean the lowest pressure extends from the southern point of Alaska westward over the Aleutian Islands. An area of high pressure between the Rocky Mountains and Hudson Bay, and connected with the high pressure of northern Siberia, separates the low areas of the Atlantic and the Pacific. The general distribution of the pressure is, therefore, symmetrical, not with respect to the north pole and the equator, but rather to a line drawn from Manitoba to the Sea of Baikal, in Siberia. These pressures are as given by the mercurial barometer, uncorrected for the variation of gravity with latitude.

As compared with February the normal pressure for March is lower by 0.10 in Manitoba, Assiniboia, and Saskatchewan, as also along the middle and east Atlantic coasts to Newfoundland and the mouth of the St. Lawrence, but it is higher by 0.15 over Greenland, Iceland, Ireland, Spitzbergen, and the intermediate ocean.

The departures of normal monthly pressure for March from the annual normals for the Northern Hemisphere show a deficit of 0.10 over the Atlantic southeast of Nova Scotia and Newfoundland, and, therefore, decidedly south of the region of lowest pressure; this location to the southward is, to a considerable extent, explained as the effect on the mercurial barometer of the variations of gravity with latitude.

The tracks pursued by storm centers, as well as their average velocity and frequency, differ but little from those of February. The regions over which the greatest number of storm centers pass are as follows: 43 near Lake Superior; 44 between Cape Cod and Nova Scotia; 34 east of Newfoundland, at about N. 47°, W. 45°; 20 between Iceland and the Orkneys; also in northern Norway and Sweden and in central Italy. The average velocity of movement for the United States is 33 miles per hour, and for the North Atlantic Ocean 22 miles from west to east. On the average one storm traverses successively both the North American continent, the Atlantic Ocean, and Europe during the month of March.

NORTH ATLANTIC STORMS.

The paths of the following areas of low pressure and strong winds on the Atlantic Ocean during March, 1894, have been approximately traced on daily charts of simultaneous observations received through the co-operation of the Hydrographic

Office, U. S. Navy, and the "New York Herald Weather Service:"

A. Central, 1st, Greenwich noon, N. 60°, W. 8°, and was a continuation of area *L* in the series for February. Pressure was at this time high over southern Europe and the entire Atlantic south of N. 45°, and continued high in the eastern portion of this region for several days; 2d, noon, central N. 62°, W. 4°; 3d, noon, N. 65°, E. 22°; 4th, noon, N. 65°, E. 50°; the central lowest pressure had by this time steadily risen, and having passed into the region of the Ural Mountains, was probably entirely broken up.

B. This represents the western portion and a subdivision of area *A*, and probably originated on the 3d south of Iceland, and in the usual manner by the inflow of cold, northwest winds into the southwest end of a general depression; it was central, 4th, noon, at N. 62°, W. 5°; 5th, noon, in southern Sweden and the Baltic Sea, where it disappeared.

C. This was a continuation of U. S. series No. II. On the 2d a depression existed between the Atlantic coast and Bermuda, approximate location of its center, N. 32°, W. 32°; 3d, noon, N. 42°, W. 57°; by this time it had developed into a severe hurricane; 4th, noon, N. 43°, W. 52°; 5th, noon, the center had apparently rapidly filled up and only a slight depression was left at N. 44°, W. 48°, while a more important trough of low pressure was developing to the northward. The *Edam*, at 7 p. m., was at N. 41° 47', W. 57° 21', barometer 28.92.

D. This depression was central on the 6th, noon, at N. 60°, E. 2°, and on the 7th, noon, at the southern end of the Baltic, N. 54°, E. 15°. At this time there was a series of five depressions and cyclonic whirls extending from the Baltic to the coast of British Columbia.

E. 7th, noon, N. 58°, W. 20°; 8th, noon, N. 60°, W. 10°; 9th, noon, N. 60°, W. 10°; 10th, noon, N. 60°, W. 10°; 11th, noon, N. 59°, W. 8°; 12th, noon, N. 63°, E. 4°; here this special whirl and depression seems to have broken up on the coast of Norway while, at the same time, on its immediate western side a new one (*F*) developed over Scotland.

F. 13th, N. 60°, W. 2°; 14th, N. 64°, E. 6°; 15th, N. 70°, E. 20°. Simultaneously with the development of *F* the general barometric depression extended rapidly southward into the Mediterranean, and on the 14th, 15th, 16th, and 17th, a minor depression passed from Corsica eastward to the Baltic.

G. This was a continuation of low area No. VII, U. S. series, which was in British Columbia on the 7th and at the mouth of the St. Lawrence on the 12th, where it probably broke up and a new area formed at the southern extremity, whose center, on the 13th, noon, was at N. 42°, W. 62°; 14th, about N. 46°, W. 55°, after which this center was broken up and merged into the following one.

H. A continuation of U. S. series No. IX, and was central